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## FEATURES OF THE GEOLOGICAL AND GEOMORPHOLOGICAL STRUCTURE OF THE ACCUMULATIVE FORMATIONS OF THE NORTH PRYAZOVIA

**Assistant Professor, Oleksandr Nepsha**

**Associate Professor, PhD (Geography) Svitlana Hryshko**

**Associate Professor, PhD (Geology) Larysa Prokhorova**

Bogdan Khmelnytsky Melitopol State Pedagogical University, Melitopol, **Ukraine**

### ABSTRACT

The modern geomorphological appearance of the northern coast of the Sea of Azov was formed during the last 2 thousand years under the conditions of modern neotectonics, intensive hydrodynamic regime, and abrasion and accumulative processes. At the same time, most of the accumulative forms of the North Pryazovia region – sea spits – were formed.

In geomorphological terms, the spits of the northern coast of the Sea of Azov are lowlands, in the form of sandy and shell peninsulas, which wedge deeply into the water area of the Sea of Azov at an angle of about 45° to the conventional coastline. These spits are oriented in the northeastern and southwestern directions.

The generalization of the results obtained in the course of the research made it possible to establish the main features of the geological and geomorphological structure of the accumulative forms of the North Pryazovia, in connection with the geological structure and marine hydrometeorological conditions; to develop a generalized scheme of morphogenetic dissection of «Azov type» spits.

**Keywords:** North Pryazovia, sea spits, geological and geomorphological structure, accumulative formations, morphogenetic dissection of spits

### INTRODUCTION

The geomorphological feature of the northern coast of the Sea of Azov is the presence of accumulative formations – spits and barrows. Spits of the northern coast of the Sea of Azov cannot be considered in isolation from one another and from those processes that are directly involved in their formation. They arose as a clearly organized system of spits, the so-called «Azov type», which differ from similar formations in other regions of the world and are in fact unique in space and time, that is, unique in their own way.

Spits and peresyps are located on the northern coast of the Sea of Azov within the Kherson, Zaporizhzhia and Donetsk administrative oblast of Ukraine. These are Fedotova Spit (45 km), Obytichna (30 km), Berdianska (23 km), Bilosaraiska (14 km), Kryva (10 km) and a number of small spits that protrude into the sea for 1-2 km: Samsonova, Bezimenna, Shyrokyńska, Liapinska, and Peresyp of Molochnyi Estuary. Comprehensive geological and geophysical studies [1-3, 11, 12] have shown that they are all confined to grabens, and not to horsts. At the same time, the Nogayskyi and

Obytichnyi faults control the Obytichnyi graben, Berdianskyi and Novopetrivskyi border the Berdyanskyi graben, Bilosaraiskyi and Kalmiusskyi – Bilosaraiskyi graben. This suggests a relative instability of coastal spits, especially under unjustified anthropogenic impacts – sand extraction, construction of large objects, which leads to the destruction of primarily geological structures, primarily littoral swells [5].

## **METHODS OF RESEARCH**

The scientifically-research work of the Department of Physical Geography and Geology of Bogdan Khmelnytsky Melitopol State Pedagogical University is connected with the study of the dynamics of the geological-geomorphological processes of the North-Western Pryazovia, the geo-ecological problems of the maritime territories.

The modern geological-geomorphological data on the structure and the configuration of the shores of the north-western coast of the Sea of Azov, the results of our own geological research (2008-2021) have based in the article. During the definition of the types of the banks of the north-western coast of the Sea of Azov, the authors have used the works of V.R. Zenkovych [12, 13] and Yu.D. Shuiskyi [15], V.A. Mamyikina [7, 8] and Yu.P. Hhrustalev [7], and the results of the personal field expeditionary and the stationary research in the coastal zone of the Sea of Azov.

The aim of the work is to characterize the modern geological and geomorphological structure of the spits and peresyps of the northern coast of the Sea of Azov. Based on the purpose of the study, we set the following tasks: to analyze the location of the Azov spits in connection with the tectonic structure of the territory; to analyze the features of the geomorphological structure of the spits of the northern coast of the Sea of Azov; to develop a generalized scheme of the morphogenetic structure of the «Azov type» braids. As a result of the study, bibliographic methods were used, which made it possible to analyze the historical section of the geological and geomorphological structure and climatic conditions of the northern coast of the Sea of Azov; statistical methods were used to analyze the dynamics of geological and geomorphological processes and climatic features of the northern coast of the Sea of Azov in time; cartographic methods were applied to analyze the current state of accumulative formations of the coastal zone of the Sea of Azov and to determine the degree of distribution of various forms of relief; field research methods were the main ones and were used for continuous monitoring of the modern dynamics of accumulative formations on the northern coast of the Sea of Azov. The use of the entire complex of the above methods allows us to study the dynamics of the development of accumulative formations on the northern coast of the Sea of Azov from the point of view of its past and future trends.

## **DISCUSSION**

The Sea of Azov has characteristic features – shallow water and rugged coastline, which is confirmed by the presence of spits, barrows and bays. They develop under conditions of an acute shortage of sediments and strong wave impact, mainly with rather steep slopes of the coastal sea bottom. Therefore, most barrows and spits are characterized by a destructive development regime and a gradual retreat of the coastline. The coastline of the beach is continuously shifting towards the land, the retreat rate in different areas is 0.1-4.8 m/year [8], this led to the fact that a special landscape system appeared on their

surface, which consists of three main elements, or «zones»: a sea beach, a strip of aeolian forms and a low marshy saline surface in the rear adjacent to the estuary (lagoons, bays). Each of these «zones», located along the entire length of the spit or peresyp, is formed by the corresponding factors [13]: marine hydrometeorological factors; wind and seawater surges; hydrodynamic factors of estuary.

Aeolian landforms spread along the narrow peresyp and spits (up to a maximum of 90-110 m), in places – in the form of a discontinuous strip, in the form of one or two ridges, with accompanying additional dunes on the inner part of the accumulative form. The highest is the ridge from the sea edge of the strip. It determines the height of the form in general – more often up to 1.5-2.5 m, maximum – up to 5.8 m. The maximum is observed in wide areas of spits and peresyp (spits: Kryva, Bilosaraiska, Berdyanska, Obytichna, Peresyp of Molochnyi Estuary, Fedotova, Spit of Biryuchy Island). Dunes are formed under conditions of permanent movement of accumulative forms and their changes over time. All of the above morphological and landscape features of coastal aeolian forms are fundamentally different from those that occur in sandy deserts. Corresponding differences in the coastal zone of the seas are inherent in the aeolian process in general. In general, the coastal dunes within the aeolian landscape strip act as a regulator of the stability of accumulative forms in general [2, 3].

The modern geomorphological appearance of the northern coast of the Sea of Azov has been formed during the last 2 thousand years under conditions of an intense hydrodynamic regime and abrasion-accumulative processes. At the same time, most of the accumulative forms of North Pryazovia were formed [10].

Quaternary deposits in the form of sands, clays, detritus, shells and others occur on the spits of the northern coast of the Sea of Azov or nearby. Thus, in the Obytichna Spit area, ancient Euxinian deposits were discovered. On Fedotova Spit – Karangat deposits. On Bilosaraiska, Berdyanska and Obytichna spits – New Euxinian deposits. In the relief of the spits of the northwestern coast of the Sea of Azov, a number of regularities were revealed: they all have a triangular shape, located near the mouths of the rivers – Bilosaraiska, Berda, Obytichna. At their base, the braids are joined to the shore. Their surface is slightly wavy, the eastern coast (windward) is higher, the western one is gently sloping. There are numerous salt lakes in the coastal bases of the spits. A number of researchers associate the formation of spits on the northern coast of the Sea of Azov with the effect of storms arising from northeastern winds. V.P. Zenkovych [15] explains this by the well-known law of wave activity: if waves propagate at an angle less than  $45^\circ$  to the coast, then all spits are directed into the open sea. In addition to these reasons for the formation of spits, structural explanations for their genesis are known. The location of the spits on the coast of the Sea of Azov is determined by the peculiarities of the geological structure of the basement, which is submerged, and its fragmentation into blocks. The areas of the lowered blocks are the places where the spits grow [2, 3]. The prevailing winds contribute to the gradual displacement of the accumulative streamers in the westerly direction as a result of erosion and retreat of the eastern coast and alluvial west coast. The main processes that determine the specifics of the interaction between land and sea and the features of the coastal landscapes of the northwestern coast of the Sea of Azov are the surf activity of waves (abrasion and accumulation), alongshore currents with the corresponding transfer of marine sediments of abiogenic and biogenic origin, as well as overshoot phenomena [9, 14].

The specificity of surf activity on the northern coast of the Sea of Azov is associated with the configuration and direction of the coastline and with the prevailing direction of winds in the study area. The elongation of the coastline from northeast to southwest actually coincides with the prevailing northeasterly winds, and in relation to the easterly winds, the coastline is at a very acute angle. The general pattern in the formation of spits (Fedotova, Obytichna, Berdyanska, Bilosaraiska and Kryva) is their elongation from northeast to southwest due to the dominant northeast and east winds and the corresponding direction of the surf flow. The alternation of northeastern and southwestern winds causes a gradual displacement of the Azov spits of the northern coast to the west, while the windward (eastern) coast is deepened due to the prevailing removal of sandy-shell deposits by northeastern winds, and the leeward (western) coast is in as a result of alluvial and deposition of sedimentary strata it is shallow [4, 6]. Sediment deposition on the western coast of the triangular spit base also occurs under the influence of southwesterly winds in summer. At the same time, circular currents appear in the bays of spits with clockwise movement of water, as a result of which not only the triangular base of the spit is built up, but also the entire western coast of each spit [15].

The displacement of the streamers in the westerly direction is not parallel: the southern part of each streamer is displaced at a slightly higher speed, as a result of which there is a gradual stretching of the spits along the coast. Complications of the coastline by accumulative streamers led to certain transformations in the circulation of coastal waters – the development of alongshore currents along the eastern coast of spits, coastal currents along the western coast and special circular currents in bays, which change their direction depending on the prevailing winds [10, 11].

## RESULTS

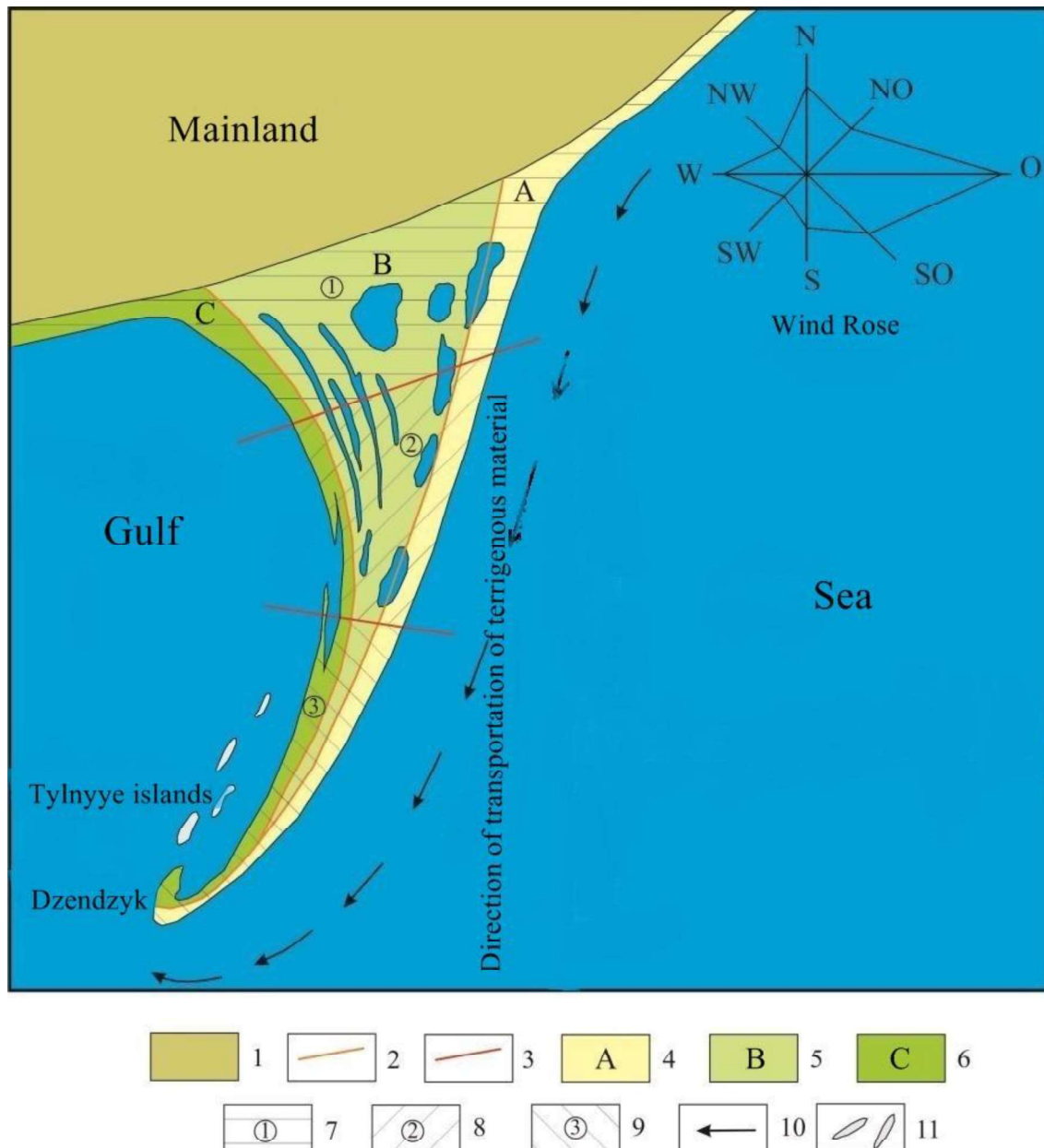
The uniformity of the topography of the braids does not exclude significant individual features of each spit, although the presence of common features is inherent in the spits, which are fully expressed only on well-developed type spits, namely the “Azov type” spits. We have presented these general features schematically in the form of morphogenetic dissection of the Azov spits (Fig. 1). In the presented diagram, longitudinal and transverse zones were identified.

The longitudinal zones of the Azov spits have the following structure:

A – frontal (littoral) – relatively high littoral swells are formed here, due to the influence of the prevailing eastern winds and strong storms, which cause powerful wave activity and intensive transport of terrigenous material along the coast.

B – medial – the most balanced morphologically and the least accessible for the destructive action of sea storms, but depends on the effects of the surge phenomena.

B – rear – is largely similar to the frontal zone, however, it is devoid of intense and superior destructive effects of storms and deposits of coarse-grained terrigenous material.



**Figure 1.** Scheme of morphogenetic subdivision of «Azov type» spits

Legend: 1 – mainland; 2 – the border of the longitudinal zones; 3 – the border of the transverse zones; 4 – frontal (littoral) longitudinal zone; 5 – medial longitudinal zone; 6 – back longitudinal zone; 7 – continental transverse zone; 8 – median (central) transverse zone; 9 – apical (end) transverse zone; 10 – direction of transport of terrigenous material; 11 – rear islands.

In the rear zone from the side of the shallow bay, biogenic material (dam mixed with shells) is often carried out by storms, from which a new swell is formed in the surf section at a certain distance from the previous one, and the gap between the swells turns into a narrow elongated estuary. In addition to longitudinal zones, transverse zones are distinguished on spits:

1) continental – characterized by the predominant influence of continental processes: the desalination effect of groundwater wedging out from under the continental slope;

aeolian activity in zone A1 (frontal continental) by the spread of a system of internal estuaries, which periodically dry up or are flooded by surge sea waters; zone B1 (medial-continental);

2) the middle (central) is more dependent than the previous one on the impact of the sea; in zone B2 (central-medial), a significant number of saline-water estuaries are concentrated;

3) the terminal (terminal) is very dependent on the influence of the sea.

The modern relief of spits in some areas is significantly complicated by artificial forms of anthropogenic origin – dams, embankments for paved roads, drainage channels and ditches that overlap during storms, fish breeding ponds, artificial rise in built-up areas of spits, coastal protection structures, the fence of a layer of sand-shell material for construction needs, former quarries after sand extraction, filled with waters.

## CONCLUSION

The modern geomorphological appearance of the northern coast of the Sea of Azov has been formed during the last 2 thousand years under conditions of an intense hydrodynamic regime and abrasion-accumulative processes. The length of the Azov spits has a meridional direction, which is directly related to the tectonic structure of the territory and is confined to grabens, which are limited by faults. Geomorphologically, the spits of the northern coast of the Sea of Azov are low-lying wedge-shaped sand-shell peninsulas that deeply enter the water area of the Sea of Azov at an angle of about 45° to the conventional coastline and are oriented from northeast to southwest due to the dominant northeast and east winds and the corresponding direction of movement of the surf stream. The alternation of northeastern and southwestern winds contributes to the gradual displacement of the Azov spits to the west, while the windward (eastern) coast is deepened, due to the prevailing removal of sand-shell deposits by northeastern winds, and the leeward (western) due to the washout and deposition sedimentary strata are shallow. Neogene-Quaternary deposits take part in the geological structure of the Azov spits.

As a result of the studies, a generalized scheme of morphogenetic dissection of the Azov spits was developed, which is the presence of longitudinal (frontal, medial, dorsal) and transverse (continental, median, apical) «zones».

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